

On Friday, the 29th, the visitors will be taken to Grimsby and given an opportunity of seeing the results of economic work in the Niagara fruit district. As the Toronto National Exhibition will be going on that week, reduced railway fares will be available from many points to that city.—C. J. S. B.

NEW SPECIES AND NEW LIFE HISTORIES OF EPHEMERIDÆ OR MAYFLIES.

BY W. A. CLEMENS, TORONTO, ONT.

While at the Go Home Bay Biological Station on Georgian Bay, during the summer of 1912, I made a special study of the Ephemeridæ of that district, under the direction of Dr. E. M. Walker, to whom I am much indebted for advice and kindly criticism. A full account of the investigations will appear in the report of the Marine Biological Stations of Canada, this paper being confined chiefly to new species and new additions to the life-histories of several forms.

The work was carried on from May 25 to September 10, and consisted chiefly in the collecting and rearing of nymphs or larvæ. Collections were made in as varied localities as possible, as there are nymphs for almost every condition of fresh water. The nymphs were taken to the laboratory in jars or bottles of water, where they were examined under the binocular microscope and the species separated. A number of each species were then transferred to breeding jars, which consisted of glass vessels, fitted up as nearly as possible to the conditions in which the nymphs were found, and supplied with running water. Over the jars, wire cages were placed to catch the subimagos as they emerged. As the subimagos appeared, they were transferred to other vessels, where they were kept until the final moult, which usually took place in a day or two. The imagos were killed with potassium cyanide and then preserved dry or in alcohol. The subimago exuvial and final nymph sloughs were also preserved for future reference. In this way about 180 specimens were bred out during the summer. The following is a list of the forms taken:

August, 1913

- Subfamily: Ephemerinae 1. *Hexagenia bilineata* Say.
 2. *Ephemerella simulans* Walker.
- Subfamily: Heptageninae 1. *Heptagenia flavescens* Walsh.
 2. " *lutea* sp. nov.
 3. " *fusca* sp. nov.
 4. " *tripunctata* Banks
 5. " *rubromaculata* sp.
 nov.
 6. " *luridipennis* Burm.
 7. " *canadensis* Walker
 8. " *frontalis* Banks.
 9. " sp.? (nymphs only).
 10. *Ecdyurus maculipennis* Walsh.
 11. " *lucidipennis* sp. nov.
 12. " *grandis* sp. nov.
- Subfamily: Baetinae 1. *Baetisca obesa* Walsh.
 2. *Leptophlebia*, sp.? (nymph only).
 3. *Blasturus cupidus* Say.
 4. *Blasturus nebulosus* Say.
 5. *Choroterpes* (?) *basalis* Banks.
 6. *Ephemerella lutulenta* sp. nov.
 7. *Ephemerella lineata* sp. nov.
 8. *Ephemerella bicolor* sp. nov.
 9. *Drunella* sp.? (nymph only).
 10. *Cænis diminuta* Walker.
 11. *Tricorythus allectus* Needham.
 12. *Chironetes albomanicatus* Need-
 ham.
 13. *Siphilurus flexus* sp. nov.
 14. *Baetis propinquus* Walsh.
 15. *Clæon dubium* Walsh.
 16. *Callibatis ferrugineus* Walsh.

DESCRIPTIONS AND NOTES.

Genus HEPTAGENIA

Special attention was given to this genus on account of its abundance and the comparatively large number of species. The

nymphs of eight species were taken and imagos reared, three of which are new species and the nymphs of the other five have not previously been described. The *Heptagenia* nymphs were the dominant forms in the swift waters and along the exposed shore. Their bodies are very much flattened, legs spreading, femora flattened, claws pectinated, gills placed dorsally in an overlapping series, and eyes on dorsal surface of head, and so are adapted to a life in the swiftest water. They are able to cling very tightly, for when they are lifted from a stone, quite a resistance can be felt. The clinging habit is very strong, for if a number are placed in a vessel of water without anything else to cling to, they begin clinging to each other and are soon all in a mass. They are quite active and are able to scurry over the surface of a stone, even going sideways and backwards. Their food consists of the various algal forms on the stones to which they cling.

A *Heptagenia* probably completes its life cycle in a year. It spends all its life in the water except for four or five days as subimago and imago. The egg hatches in about 40 days. This calculation is based upon the fact that about two months after the appearance of the imagos of *H. tripunctata* the small nymphs of the next generation were found, and this is the time required for the eggs of *Hexagenia bilineata*. The nymphs moult about once every two weeks, and as the time of emergence approaches, they probably migrate into quieter water. I have not observed the emergence of a *Heptagenia* subimago in the open, but in the laboratory the nymphs would crawl up the sticks placed in the jars for the purpose and transform just above the water level. The subimago stage usually lasts a day, but occasionally only a few hours and in the early part of the season it frequently lasted three or four days. Temperature and humidity seemed to be important factors. The imagos commenced their flight shortly after sundown along the lake shore, dancing in their rhythmic up and down manner at a height of from 12 to 20 feet. The females deposited their eggs by flying over the surface of the water and brushing off the eggs into the water as they appeared from the openings of the oviducts. Of the eight species the first to appear was *H. tripunctata* about June 1, and the last, *H. luridipennis*, September 2.

There are two distinct groups. In the first, consisting of *H. tripunctata*, *H. luridipennis*, *H. flavescens*, *H. lutea*, *H. fusca*, *H. rubromaculata*, the nymphs are characterized by having the lamellæ of the gills oblong, claws usually pectinated, distal segment of maxillary palpus thickest about its middle and with a small tuft of bristles near its distal end. The body is much flattened and the colour olive brown or greenish yellow. The male imagos have the penis lobes rather L-shaped and the second and third tarsal segments of the fore legs are equal, while the fourth is about four-fifths the length of the second. In the other group, consisting of *H. canadensis*, *H. frontalis*, and a third undetermined species represented by the nymph only, the nymphs have the lamellæ of the gills oval and produced distally into a sharp point; the claws are not pectinated, the distal segment of the maxillary palpus thickest towards the distal end and the tuft of bristles larger than in group 1. The body is less flattened, more reddish or yellowish, and has the appearance of being striped longitudinally on dorsal surface of abdomen. The male imagos have the penis lobes oblong instead of L-shaped and the second and third tarsal segments are not quite equal, while the fourth segment is about half the length of the second.

The following keys will serve to separate these eight species:

Key to Male Imagos:

A. No black spots or bands on face below antennæ. Group 1.

B. Very pale species.

C. Notum ferruginous, stigmal dots

distinct..... *H. flavescens*.

CC. Notum lighter, no stigmal dots..... *H. lutea*.

BB. Dark species.

D. Large, entirely brown species.

E. Thorax with a broad dark median stripe or two narrow stripes close together..... *H. verticis*.

EE. Thorax without dark median stripe..... *H. fusca*.

DD. Not entirely brown.

F. Two very small dots on median carina between antennæ.....*H. tripunctata*.

FF. No dots on median carina; thorax and top of abdomen dark.

G. Reddish area in pterostigmatic space of wing...*H. rubromaculata*.

GG. Without reddish area in wing....*H. luridipennis*.

AA. Two black spots or bands on face below antennæ. Group 2.

H. A black band on face below antennæ, a dark dash in wing, abdomen dark..*H. canadensis*.

HH. A black spot on face below antennæ, no dash in wing, abdomen lighter..*H. frontalis*.

Key to Nymphs :

A. Gills oblong.

Group 1.

B. Nymphs entirely brown, without a distinct dorsal colour pattern.

C. An inverted dark U-shaped mark on ventral surface of 9th segment and a dark spot on ventral surface of the 8th. Dorsal surface of body has a smooth appearance.....*H. flavescens*.

CC. A row of dark mushroom-shaped marks along ventral surface and a rectangular dark mark on 9th. Dorsal surface has a rather granular appearance and lateral margins of body quite hairy.....*H. rubromaculata*.

BB. Nymphs not entirely dark brown and have a distinct colour pattern.

D. Ventral surface of abdominal segments banded with dark bands along posterior margins.

E. Broad dark bands at posterior margin of each segment on dorsal surface.....*H. fusca*.

EE. Dark bands at posterior margins of segments 7, 8, 9 and 10; not as broad as preceding species and a more elaborate colour pattern.....*H. lutea*.

DD. Ventral surface not banded.

F. Two rows of black dots along ventral surface of abdomen.....*H. tripunctata*.

FF. No dots.....*H. luridipennis*.

AA. Gills oval and pointed.

Group 2.

G. Two light longitudinal stripes on dorsal surface of abdomen close to median line.

H. Stripes fairly uniform for entire length. Reddish species
.....*H. canadensis*.

HH. The stripes not of uniform width, very wide on 8th segment, very narrow on 5, 6 and 7, so that darker intermediate parts have oval shapes. Lighter species. *H. frontalis*.

GG. Dorsal surface of abdomen has appearance of three longitudinal dark stripes. Colour greenish yellow. *H.*, sp. undetermined.

Mr. Nathan Banks kindly identified the imagos for me and loaned me specimens of *Heptagenia verticis*, *H. luridipennis* and *H. terminata*, for comparison.

Heptagenia flavescens, Walsh.

Nymph.

Measurements: Body 8-9 mm.; setæ 10-13 mm. Head brown, very slightly covered with light dots; a light spot above each ocellus; a small light dot on each side of median ocellus; an irregular light area anterior and lateral to each eye. Pronotum brown, with two light spots on each side. Mesothorax similar in colour to prothorax. Abdomen of a uniform brown colour dorsally, having a smooth appearance; lighter ventrally, with a semicircular brown band on 9th segment and a median brown spot on 8th. Spines of lateral edge short. Setæ banded, usually three segments dark and one light, sparsely fringed, usually only at base of light segment. Femora much flattened, brown and dotted with light spots, and having three irregular light bands; covered dorsally with small spines and posterior margin fringed with hairs and spines. Tibia with median and distal light bands. Tarsus tipped with white. Claws with two pectinations.

The nymphs of this species were taken up the Go-Home River on June 16, 1912, immediately above Flat Rock Falls, where the water was flowing swiftly but smoothly. They were clinging to stones in water one to one-and-a-half feet deep not far from the shore. On the same date they were found just below Sandy Gray Falls, two miles farther up the river. Here the water was swift and rough. I was successful in rearing only two specimens, the dates being June 27 and July 3.

Heptagenia lutea, sp. nov.

Male imago.

Measurements: Body, 9-10.5 mm.; wing, 10.5 mm.; setæ, 20; fore leg, 10.

This is a light-coloured species, slightly reddish on face below antennæ; reddish brown between ocelli and eyes. Thorax almost whitish yellow dorsally, light yellowish brown laterally; a dark area on each side of pronotum, slight red and brown markings below bases of fore and hind wings. Each abdominal segment 1-8 banded dorsally at posterior margin, remaining part of these segments being almost white; segments 9 and 10 entirely reddish brown; stigmal dots not marked; wings clouded in pterostigmatic

space, a few cells reddish. Femora with median and apical bands; tibia-tarsal and tarsal joints black; fifth tarsus and unguis dark.

Female imago.

Measurements: Body, 11 mm.; wing, 12; setae, 22; abdomen more yellowish than male.

Nymph.

Measurements: Body, 10 mm.; setae, 13-16 mm. Head, light brown in colour and dotted with light dots; light areas over ocelli; another at posterior margin of head in median line and a larger one lateral to each eye. Pronotum with a broad, colourless lateral margin; remainder light brown, with numerous irregular light spots. Abdomen darker dorsally and with a rather complicated colour pattern. First segment light, with two brown areas at side; second with a narrow brown band along posterior margin and five brown areas and four light ones placed alternately; third almost entirely dark, with a few light dots; fourth with two dark spots in posterior lateral angles of segment, also a large dark area in centre of segment with a light area within it; fifth with a dark spot in each posterior lateral angle as in preceding segment, a dark band along posterior margin, two light areas surrounded with brown and a dark spot in centre of each; sixth almost entirely brown except for two light areas in anterior lateral angles; seventh with two large light areas, with a brown dot in each toward inner side; eighth an irregularly light and dark coloured segment; ninth has a narrow brown band along posterior margin and a dark longitudinal stripe in median line; tenth almost entirely dark. Ventrally, the lateral and posterior margins of segments 2-8 dark; segment nine with two large brown spots. Setae greenish; basal half well fringed at joints, distal half with each two segments alternately light and dark and few hairs at joinings. Femora with alternately light and dark irregular bands and covered with minute spines dorsally; posterior margins fringed with hairs, anterior margins also fringed, but hairs shorter. Proximal ends of tibiae dark and have dark bands slightly beyond middle. Tarsi with reddish-brown bands very near proximal ends. Claws with two pectinations.

These nymphs were very abundant along the open shore of Station Island and west of it, my collection dating from June 3 to July 2. A few were taken in a rapid on the Muskosh River on June

30 and several small specimens from Sandy Gray Falls, August 23. Imagos were reared from June 27 to July 3.

Heptagenia fusca, sp. nov.

Male imago.

Measurements: Body, 10 mm.; wing, 13; setæ, 26; No markings on face; ocelli almost in a straight line, the middle one the smallest. Pronotum brown, slightly darker along the median line; mesothorax uniformly brown. Abdomen with posterior one-third of each segment of same brown colour as thorax and projections from this band anteriorly in the median line, almost forming a continuous longitudinal stripe on the abdomen; the band widens laterally also; remaining portions of each segment somewhat light brown; ventrally very slightly banded. Forceps and penis lobes of usual form. Femur banded in middle and at distal end. Wings large; costa, subcosta and radius light in colour, while remainder of longitudinal and the cross veins brown. No cloud in pterostigmatic space.

Female imago.

Measurements: Body, 10-12 mm.; wing, 14 mm.; setæ, 18; Quite similar to male, except that abdomen is considerably darker.

Nymph.

Measurements: Body, 12-14 mm.; setæ, 15-20; antennæ, 3. Head brown, dotted with light spots; usually three light areas at posterior margin between eyes and two lateral to each eye; anterior margin well fringed with hairs. A light longitudinal median line on pronotum; two light areas on each side and lateral margin colourless; remainder of pronotum brown, with small light dots. Posterior one-third of each abdominal segment 6-10 almost black; segments 1-6 brown; the remainder of each segment varying from light brown to greenish yellow; ventrally posterior one-fourth of each segment 2-8 brown; ninth segment has two dark areas laterally. Femur light brown on upper surface, with a few lighter areas and covered with minute spines dorsally; posterior margin fringed with hairs; proximal end of tibia dark brown and its third quarter dark; proximal half of tarsus dark. Setæ well fringed with hairs at the joinings.

While on a canoe trip up the Go-Home River, June 16th, I collected a number of the nymphs of this species just below Sandy

Gray Falls. The only imagos I have are those bred from this collection. The dates of emergence are June 23rd and 24th.

This species is close to *H. verticis*, but lacks the dark median stripe on the thorax, and does not show the slightest trace of a dash in the wing under the bulla.

Heptagenia tripunctata, Banks.

Nymph.

Measurements: Body, 11-14 mm.; setæ, 12-16. Head deep brown, occasionally almost dark dotted with light spots; three light spots; three light areas along anterior margin of head and one at posterior margin between eyes. Pronotum similar in colour to head, with light dots and about five larger light areas on each side; lateral with a light area which extends inwards some distance. A light area in antero-lateral angle of mesothorax. Femur stout, with five irregular light areas; small spines very numerous; posterior margin fringed with hairs. Tibia with two dark and two light areas, arranged alternately. Abdomen similar in colour to head and thorax; a light area on segments 4 and 5 containing a small triangular dark area at anterior margin of segment 5, lateral to which are two dark dots; another light area on segments 7, 8, 9 and 10 containing two dark dots on 8th and two on 9th segments; usually three small dark dots at posterior margin of each segment. Ventrally two longitudinal rows of dark dots, increasing slightly in size toward posterior end; segment 9 usually with two pairs, the anterior pair small, posterior pair larger. Setæ with alternate dark and light areas. Gills have the lamellæ slightly rounded at distal end.

The nymphs of this species were seldom found in swift water, but were everywhere abundant about Go-Home Bay, in quiet bays, along open shores and in quiet streams. They could be found at any time during the summer. The first bred specimens emerged May 31, but the first capture was not made until June 11. On this date a small swarm of about 20 individuals was discovered about 8.15 p.m. flying from 10 to 20 feet high along the shore of Station Island, facing north. One female and several males were taken. Soon after this they became very abundant and remained so until about July 5th. The last bred specimen is dated Aug. 13.

Heptagenia rubromaculata, sp. nov.

Male imago.

Measurements: Body 8 mm.; wing 8; setæ 17; fore leg 7. No markings on face; darker spot at posterior margin of head between eyes. Thorax dark; median longitudinal dark stripe on pronotum; dark brown stripe on coxa of fore leg and extending up the side of prothorax. Abdominal segments 1-7 light; 8-10 dark, similar to thorax; each segment banded at posterior margin; stigmal dots distinct; wing has a reddish area in pterostigmatic space.

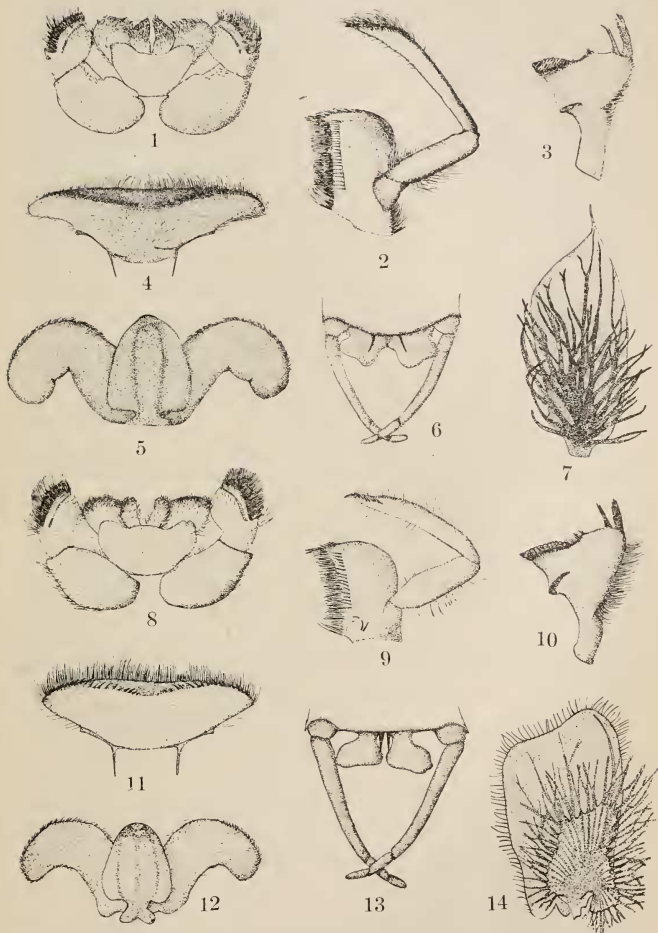
Female imago.

Measurements: Body 9-9.5 mm.; wing 13-14; setæ 15-22; often slightly reddish on face beneath antennæ. Dark brown on dorsal surface of head behind ocelli. Abdomen varies from reddish to a yellowish colour in dried specimens.

Nymph.

Measurements: Body 9-10 mm.; setæ 10. Head dark brown, dotted with minute light spots. Pronotum similar in colour to head; two light areas on each side, the outer one sometimes joined to the light margin. Abdomen dark brown, with a granular appearance; sometimes a faint, broad, dark, longitudinal streak can be made out with two dots on each side of it on each segment excepting 9 and 10; ventral surface lighter, with a median row of irregular dark spots and lateral rows of small dots or lines; the median dots are sometimes broken up so that only four or five small dots remain in its place; on segment 9 the markings are usually joined, forming roughly three sides of a square. Femur with four irregular dark bands; both posterior and anterior margins very hairy; claws pectinated. A very hairy species, having anterior margin of head, sides of thorax and abdomen very hairy.

This nymph was first taken on June 15 in what is commonly called the Narrows, near the mouth of the Go-Home River. The water here had a well-marked current, but not swift. On June 30 I found them very numerous in the very swift water of a rapids near the mouth of the Muskosh River. Nearly a month after this, on July 20th and 22nd, I discovered mature nymphs at an old lumber chute on the Go-Home River in fairly swift water. Imagos were bred from the nymphs taken at the Narrows on June 22nd and



MAYFLY STRUCTURE (CLEMENS).

25th; in the Muskosh Rapids from July 3rd to 5th, and at the Chutes, July 24-29th.

Heptagenia luridipennis, Burm.

Nymph.

Measurements: Body 7-8.5 mm.; setæ 10-14. Head brown, with light dots; anterior margin fringed with hairs. Prothorax similar in colour to head; on pronotum a light spot on each side of median line; lateral to this another larger one, and lateral to this another which extends to the lateral margin. Abdomen similar in colour to prothorax; a row of black dots on each side corresponding to the stigmal dots of imago; segment 3 for the most part light, with a round brown spot in the median line and with two short projections laterally; segment 4 with a small triangular brown spot in median line with base to anterior margin, while apex meets a large brown area, leaving a small light area on each side of triangle; lateral to the brown area is a light one, and lateral to this again is a triangular dark spot in the posterior angle of the segment; segment 5 much like the 4th; segment 6 entirely dark, except for two small spots at anterior margin and two toward lateral margin; segment 7 with a triangular dark spot in median line, with base to anterior margin and apex reaching about middle of segment; on each side of triangle two dark spots; segment 8 similar to the 6th; segment 9 irregularly marked; roughly, it is dark, with a darker median longitudinal line, two light spots on each side and another at lateral margin; segment 10 entirely dark; ventrally there are two dark spots at lateral margins of 9th segment, just beside the lateral spines of that segment; sometimes a triangular spot in median line also. Setæ with basal half fringed with hairs.

This was the last species to be taken. On August 23rd I found them in a rapid just above Sandy Gray Falls, where the river flows through a small gorge. I was successful in rearing quite a number of imagos, dating from August 28th to September 1st. These are slightly smaller than those Mr. Banks sent me and considerably smaller than the measurements given in various descriptions.

Heptagenia canadensis, Walker.

Nymph.

Measurements: Body 11 mm.; setæ 15; antennæ 3.5. Head reddish brown in colour; a small dark area immediately in front of

each antenna, and another about the same size in front of each eye, a black dot behind each lateral ocellus; a light area in front of median ocellus, and a larger light area between each lateral ocellus and eye; another lateral to each eye along margin of head. Mouth parts of the type belonging to group 2. Pronotum reddish brown, with a dark and an approximate light area in each lateral half; margin colourless. Abdomen darker than thorax; each segment with four light longitudinal streaks, two near median line and the other two near lateral margin; black dots, corresponding to the stigmal dots just inside the lateral light streaks. Ventrally the abdomen is almost white, each segment has two light brown lateral streaks, while the 9th has its lateral and posterior margins margined with light brown. Short lateral spines at posterior lateral angles of segments 8 and 9. Setæ of equal length; light brown in colour; joinings fringed with hair. Gills oval and pointed. Femur of fore leg light brown, with four light areas; two small ones toward anterior margin and two large ones toward posterior; distal end light coloured. Femora of hind legs with fewer pale markings. Tibiæ alternately banded with brown and white; tarsi have very broad median bands; legs slightly hairy along posterior margin.

This species was very abundant at Go-Home Bay, being next in numbers to *H. tripunctata*. The nymphs were taken from May 25th to July 10th in various localities, but never in swift water, the usual place being quiet bays. Small nymphs of the next generation were found on September 5th. The first bred specimen is dated June 1st and the last July 4th. Imagos were most abundant at Station Island from June 25th to July 15th.

Heptaginia frontalis, Banks.

Nymph.

Measurements: Body 9-10 mm.; setæ 9-10; Head yellowish brown in colour; three almost round light spots along anterior margin of head; usually a light area in front of each ocellus, and another along median line between eyes and two smaller ones lateral to this along posterior margin of head. A black dot below each antenna, in front of each eye and near inner margin of each eye. Thorax lighter in colour than head; on each side of pronotum, near median line, is a small light spot; just lateral to this is a

triangular dark spot, and lateral to this again is another light area; in anterior angle of pronotum is an oval light spot; along posterior margin extending some distance on either side of median line is a broad light band, which is connected by a light longitudinal stripe along median line of mesonotum to a large irregular light area on the mesonotum. Abdomen usually a light yellowish brown; the colour pattern roughly has the appearance of a broad light band along median line, in which in segments 5, 6 and 7 are oval dark areas; in 8, a narrow stripe, and in 9 a round, dark area in each segment; on either side of this broad light band is a short light stripe; ventral surface almost white, with two lateral light brown longitudinal stripes on segments 1-9; a broad band across 9th along posterior margin, joining the two lateral stripes. Segments of setae alternately light and brown. Legs pale, colour pattern similar to *H. canadensis*.

This species was not nearly so abundant as *H. canadensis*. The nymphs were taken in similar localities, but were not so widespread or plentiful. They were found from July 15th to July 2nd and imagos were reared from June 26th to July 4th.

Heptagenia.....? (undetermined).

Nymph.

Measurements: Body, 10-11 mm.; setae, 12-13.; head, light brown; sometimes three light areas along anterior margin, but frequently the middle one is lacking and the two lateral ones are connected with the light margins lateral to the eyes. An almost black spot in centre of each half of pronotum; around this is an irregular light area, exterior to which is a brown area. Abdomen whitish yellow, with five longitudinal yellowish brown stripes in each segment 1-8. Setae light greenish yellow; joints abundantly fringed with hairs. Legs yellowish brown in colour; pattern similar to the two preceding species.

These nymphs were collected along the east shore of Manitoulin Island on June 26th, 1912, by Mr. R. P. Wodehouse, who kindly handed them over to me. As imagos were not reared, the species cannot be determined at present.



MAYFLY NYMPHS (CLEMENS).